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Final Project Report

**U.S.-U.S.S.R.
Telemedicine Consultation
Spacebridge to Armenia and Ufa**

Presented at the

**Third U.S.-U.S.S.R. Joint Working Group
on Space Biology and Medicine**

December 1-9, 1989

Moscow and Kislovodsk, U.S.S.R.



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INTRODUCTION

A devastating earthquake occurred on December 7, 1988, in Soviet Armenia. This earthquake caused widespread destruction and loss of life and property. Help, both medical and material, was rushed to the affected area and many countries, including all the Soviet republics, cooperated together to provide initial help to the victims.

Two weeks after this tragic event, a concept of telemedicine consultation was developed by the National Aeronautics and Space Administration (NASA) and proposed to the Soviet Government under the auspices of the existing bilateral Space Agreement between the U.S. and U.S.S.R. Concerning the Exploration and Use of Outer Space for Peaceful Purposes, concluded April 15, 1987, and amended May 31, 1988. This proposal was made through the established U.S./U.S.S.R. Joint Working Group on Space Biology and Medicine, and implemented from May 4 through July 28, 1989. The Life Sciences Division, with the support of the Communications and Information Systems Division at NASA Headquarters, was responsible for the U.S. implementation phase of this project; and the NPO Soyuz Medinform and "Space for Health" organization were assigned the responsibility for the Soviet portion of this project.

The goal of this activity was to provide expert medical consultation to the Armenian medical personnel in the areas of plastic and reconstructive surgery, physical and psychological rehabilitation, public health and epidemiology.

The U.S. and U.S.S.R. implementation teams developed new standards for medical information transmittal as well as protocols and schedules on how to conduct medical consultations (See Supporting Materials). The consultations were provided to the Republic Diagnostic Center in Yerevan, U.S.S.R. by four U.S. medical centers: University of Utah/LDS Hospital, University of Texas, Maryland Institute for Emergency Medical Service Systems, and Uniformed Services University of the Health Sciences.

The idea for telemedicine consultations was simple in scope. However, many technical and logistic issues had to be worked out prior to its implementation. It was determined that the two most critical periods where such help is of utmost importance are immediately after the disaster or several months later. In the immediate time frame, telecommunications are important for the purposes of patient triage, planning

for long-term care, identification of medical supplies and expertise which might be required at the scene. In the follow-on time frame, telecommunications are primarily required for treatment of chronic problems and rebuilding of medical capabilities in otherwise devastated areas. Technical problems precluded the initiation of this project in the early phase. Some of the technical issues can be summarized as follows:

1. Identification and installation of suitable ground communications links
2. Identification and securing of suitable satellite channels
3. Conformance to the existing international communications policy and procedures
4. Training of participating personnel from different countries and suitable translations
5. Privacy of medical consultations.

In this instance, Intelsat and Comsat donated free access to uplink and satellite transponders and the Soviet Union donated the downlink channels. A ground station for video, voice and facsimile communication was rented from the "Stars" company in Houston, Texas, and deployed in the Republic Diagnostic Center. Ground communication lines were provided by NASA to the U.S. medical facilities, including the use of domestic satellites for retransmission of signals. All communications were encrypted in such a way as to protect the privacy of the patients. The U.S. team visited the Yerevan Republic Diagnostic Center and got acquainted with the facilities, layouts, and capabilities existing in Soviet Armenia. The Soviet team visited the U.S. medical facilities and the NASA Goddard Space Flight Center communication center, and familiarized themselves with the U.S. medical and communications experts, procedures, and capabilities. These preliminary exchanges significantly contributed to the later success of the Spacebridge. Precise protocols and procedures were developed prior to the initiation of the telemedicine consultation network, and were amended at a later time as necessary during the telemedicine sessions. A central communication status room was established at NASA Headquarters which played the role of a "dispatcher" and assured the smooth conduct of the sessions and resolution of "conflicts."

The unfortunate railroad accident happened on June 4, 1989, near the city of Ufa, during the existence of this network. Through the efforts of the Public Service Satellite Consortium (a private U.S. organization), the NPO Soyuz Medinform, and NASA

personnel involved in the telemedicine consultation Spacebridge, a satellite station consisting of a Slow Scan Video System, donated by Colorado Video, was deployed at the Ufa Medical Center and became operational 3 weeks later. This station was connected via ground links to the "Star" station in Yerevan and was serviced by both the U.S. and Armenian expert consultants.

Overall, the project was an outstanding success. Over 400 physicians and medical personnel from both countries participated in 51 sessions during the 3 months of existence of the Telemedicine Spacebridge. Experts consulted upon 253 cases representative of the general population affected by disaster. The communication links worked very effectively. In retrospect the language differences between the different medical institutions required working adjustments both from the patient and physician standpoint. Telemedicine has been tried on many different occasions over the last 20 years; however, never before was it deployed and tested on such a large scale.

This project demonstrated both the value of such a system and the need to institutionalize this capability nationally and internationally, so that it could be activated on demand. Today, elements of telemedicine exist on a regional or urban basis in the United States and are operating quite successfully. Telemedicine is also an integral part of the manned space program. It is important, however, that serious steps are taken today to plan for the development, maintenance, and associated training on a global scale system of telemedicine with appropriately dedicated communications, medical personnel, and even rapidly deployable, self-sufficient medical care systems. Areas stricken by serious disasters usually lack of all these components which are disrupted in the immediate post-catastrophe periods. To facilitate the dissemination of the experience gained as a result of this project, the U.S. and U.S.S.R. Joint Working Group on Space Biology and Medicine has formed a joint implementation team in telemedicine charged with the specific objectives of:

1. Supporting research to advance telemedicine support for space flight
2. Recommending application of the experience to space medicine and care of sick and injured space crews
3. Recommending applicability of currently available compact and self-sustaining medical care capabilities, such as the ones developed for Mir or International Space Station Freedom, to be included into the

telemedicine system for providing immediate care to victims of natural disasters

Arnauld E. Nicogossian, M.D.

TELEMEDICINE: A HISTORICAL PERSPECTIVE

The word **telemedicine** denotes the practice of medicine at a distance. The origin of this term is difficult to establish, and it has been probably coined as a result of the space age. What really constitutes telemedicine is a point of debate. In the early days of the telephone, telegraph, and radio, medical consultations were obtained between physicians by voice or mail. A critical step which preceded telemedicine was the need for and development of telemetry. Telemetry is a process for sending or receiving measurements, either physical or biological, from remote locations. Undoubtedly, the space age and the introduction of new means for communications, both audio and video, gave a new and expanding role to telemetry, biotelemetry, and later on to telemedicine. In the early 1960's and 1970's, the spinoffs from telemetry, or better biotelemetry, found their way into doctors' offices, hospitals, ambulances, and aviation. Gradually, links between different medical centers were established which serviced not only urban but also rural areas. Implantable devices such as pacemakers and defibrillators were developed which can telemeter the data via telephone and microwave links to physician offices and be individually programmed. Thus, the combination of electronic medical systems and communications, voice or video, became an efficient way of improving patient health care, and, in essence, brought the practice of medicine to the doorstep of where the patient resides. The combined system, referred to as telemedicine, has been effectively used to augment existing health care delivery systems, by providing a direct consultation link between remotely located medical personnel working with the patient and expert consultants at a central location.

The first experiment in telemedicine was conducted in 1971 with an NPSA-launched ATS-1 satellite. Experiments in the use of telemedicine in Alaska began under the auspices of the Indian Health Service (the arm of the U.S. Public Health Service responsible for providing health care to native Alaskans). Faced with the problem of servicing scattered small villages in remote regions and thwarted by the lack of reliable communication channels in the bush, the agency turned to telemedicine in the hope that consultation on a regular basis would improve village health services.

In one of the earliest health applications, 14 villages in the central Alaskan Tanana Service unit, 1 of 7 Alaskan health service units, were chosen to participate in a telemedical consultation experiment in conjunction with a service unit hospital in

Tanana. The experiment was financed by the Lister Hill Center for Biomedical Communication, and involved daily consultation between a local village health aide and a physician at the hospital.

In addition to teleconsultation, the system was used for communications between patients at the service unit hospital and their families in the villages. Because there was no telephone service to the villages, patients had been previously isolated from such interaction. The system was also used for interactive searching of MEDLINE, the National Library of Medicine online computer retrieval system in Bethesda, Maryland, and for transmission of a continuing education course on coronary care offered to nurses by the University of Alaska.

During the year 1974-1975, NASA's ATS-6 satellite added a video component to Alaska's telemedicine experiments.

The success of the ATS experiments is well documented. The number of contacts between doctors and health aides increased by 400 percent during the first year of the experiment. The State of Alaska and the Public Health Service subsequently transferred the health demonstrations to an operational system using commercial satellite services.

Similar medical assistance was given to appropriately equipped merchant ships at sea via the MARISAT system, which routes such requests for diagnostic help to a hospital on Long Island in New York City. In the same time frame, another project was being developed to apply the experience gained as a result of the Apollo/Skylab program to the 10,000 inhabitants scattered over 4,400-square-mile Papago region. A mix of electronic technology, closed circuit color television, and computerized patient data banks was developed for this purpose. Physicians at the Indian Health Service (IHS) Hospital near the center of the region consulted via television with community health medics (paramedics), who visited patients in remote villages on a regular basis in a large van called a Mobile Health Unit (MHU). Anywhere the MHU stopped in the vast region, it had instantaneous two-way contact with the IHS hospital. This project, which was very successful, was named Space Technology Applied to Rural Papago Health Care (STARPAHC).

One piece of equipment adapted for use in the Papago health care system is a suitcase-sized emergency treatment kit that allows communication between trained ambulance attendants at an accident scene and a physician at the IHS hospital. Originally developed for medical monitoring during the Skylab program, it is now marketed commercially. This portable kit is widely used by emergency medical systems throughout the United States to provide voice and telemetry communications of vital signs, electrocardiogram (EKG), and blood pressure from a remotely located patient to a central major medical center. It has permitted paramedical personnel to provide effective stabilization and care to cardiac and trauma patients, with significant improvements in their eventual outcome and survival as a result of improved early therapy. Also included in the kit carried in the ambulance are a battery-powered defibrillator and pacemaker, oxygen supply, aspirator, resuscitator and airways, laryngoscope, prepackaged drugs and supplies, and stethoscope.

A modified emergency system is now in use in Houston, San Antonio, and Corpus Christi, Texas; Montgomery County, Maryland; Altoona, Pennsylvania; San Francisco, California; and Cleveland, Ohio.

Although the original emergency package was widely used for adult medical transports, the system has been redesigned to transport high-risk, low-birth-rate infants from small community hospitals to a central Newborn Intensive Care Unit. Combined with appropriate thermal and respiratory support, this system was placed in use in 1978 and has transported nearly 500 infants a year in Northern California over distances ranging from 50 to 500 miles.

Reliable physiological monitoring and communications permit a largely dispersed population to benefit from a rather limited supply of highly trained personnel. This allows people in remote villages to receive better treatment and allows better control over the need for patient transport to a regional center when absolutely necessary for definitive care.

In 1985, another satellite developed by NASA, ATS-3, was used to help the victims of the devastating Mexico City earthquakes. Within 24 hours after the disaster, the satellite was on the air and was used extensively by the American Red Cross and the Pan American World Health Organization.

An additional example of telemedicine is the COSPAS/SARSAT communications satellite system, which became operational in the mid 1980's. U.S., Soviet, French, and Canadian satellites maintain a constant space-based watch for distress signals from marine, air, and land operations. Since their operations began, more than 1,000 lives have been saved. Currently, more than 15 nations participate in this activity.

Two other examples include ATS-6 which was positioned over India in 1976 for one year of health, education, agriculture, and cultural experiments; and the Communications Technology Satellite (CTS), a joint NASA/Canadian experimental satellite in the early 1970's (which was the precursor of today's broadcast satellites) used extensively for health care, emergency, and education applications.

NASA's commitment to serving the public continues today using its experimental resources in the United States, the Pacific basin, the Caribbean, and most recently, the Soviet Union.

SPACEBRIDGE TO ARMENIA: BACKGROUND

The earthquake which occurred in Armenia S.S.R. on December 7, 1988, caused over 150,000 casualties as well as widespread destruction. NASA, under the auspices of the U.S./U.S.S.R. Joint Working Group on Space Biology and Medicine, made an official offer on December 12th to the U.S.S.R. Government to provide humanitarian aid in the aftermath of the tragic disaster. The Soviet authorities accepted NASA's proposal for organizing consultative medical aid involving leading U.S. medical institutions and specialists via space telecommunications.

In March 1989, physicians from NASA and four U.S. medical centers as well as communication specialists visited Moscow and Armenia to organize a Spacebridge operation. Likewise, U.S.S.R. officials from the Ministry of Health, Ministry of Post, Telegraph, and Communication, Gostel Radio Agency, and the Republic Diagnostic Center (Yerevan, Armenia) visited the U.S. in early April to finalize the arrangements. As a result of these exchanges, a Protocol and Implementation Plan (See Supporting Materials) were signed by NASA and U.S.S.R. officials agreeing to the Spacebridge which would enable Soviet physicians at the Republic Diagnostic Center in Yerevan to consult via audiovisual network with American medical specialists in four centers.

It was anticipated that Spacebridge would be in operation from May 3rd until the end of June. However, due to another tragedy, the Ufa train accident of June 4th, in which there were over 1,200 casualties, the U.S. immediately offered to extend the Spacebridge for an additional month in order to provide further consultation for these casualties. The Soviet Government immediately accepted the offer thereby permitting Spacebridge to continue until July 28th.

Once communication equipment, which was transported by Aeroflot from the U.S. to Yerevan, was installed and operational, broadcasts were able to commence on May 4th. They continued accordingly until the final day of operations on July 28th, when Spacebridge was officially terminated.

Interest in the use of telecommunications for medical purposes has grown steadily in recent years. Various nations have gained significant experience with transmitting medical information by means of digital, acoustic, facsimile and video equipment along appropriate communication channels. Modern telemedicine has taken the

following major forms: medical support of space station crews and other isolated groups; creation or improvement of access to literature in medical libraries; production of single, series and ongoing programs for educational objectives; organization of interactive medical conferences in the form of seminars, scientific discussions, and consultations; solution of administrative and practical problems associated with medical relief measures directed at elimination of the consequences of natural disasters and catastrophes.

Due to NASA's unique expertise in the application of the most advanced satellite technology to problems in public health, and to the readiness of medical personnel of four major U.S. medical centers to share their knowledge and experience, the medical personnel of the affected areas of Armenia had the opportunity to consult with American physicians on issues in a number of medical specialties. Leading specialists from the Uniformed Services University of the Health Sciences (Bethesda, Maryland); the University of Maryland Institute of Emergency Medical Services Systems (Baltimore, Maryland); the University of Texas Health Science Center (Houston, Texas); and the Latter Day Saints Hospital and University of Utah (Salt Lake City, Utah) acted as consultants for Armenian physicians for 3 months.

Medical interaction and coordination of work in the U.S.S.R. was organized by the "Soyuzmedinform" Scientific Production Agency of the U.S.S.R. Ministry of Health, which is the lead organization for the "Space For Health" program. The general director of this organization, Professor A.A. Kiselev, acted as project director for the Soviet side. The "Diagnostika" Scientific Production Organization of the Armenian S.S.R. Ministry of Health was selected as the base organization for the preparation and conduct of the teleconferences. The director of this organization, H. Nicogossian, acted as medical coordinator of the project in Armenia.

After the train crash in the Bashkir Autonomous S.S.R. in June 1989, it was decided to establish a temporary teleconferencing studio in the city of Ufa, where numerous burn cases were being treated, and to connect this studio to the Yerevan-U.S. teleconferencing network, which had already been operating for 2 months.

Thus, the "Armenia-U.S.A." medical telebridge with the "Ufa-Armenia-U.S.A." hook-up became the first example in history of the use of a system of satellite communications

in support of systematic, long-term, multidisciplinary collaboration among the medical personnel of two nations.

COMMUNICATIONS AND NETWORK

The NASA Communications Division of the Goddard Space Flight Center (GSFC), which has NASA-wide responsibility for design, implementation, operations and maintenance of the operational communications network, the Nascom Network, was given the assignment to meet the communications requirements of the Medical Spacebridge.

The communications links supporting the Medical Spacebridge between various U.S. medical centers and Yerevan, Armenia was accomplished utilizing a combination of domestic and international satellite and terrestrial networks, communications facilities and services.

The major components of the service were: a transportable C-band earth station; two INTELSAT C-band transponders; two earth stations at Roaring Creek Pa. - one for international service and one for domestic service; an AT&T domestic satellite transponder; and AT&T terrestrial private voice lines.

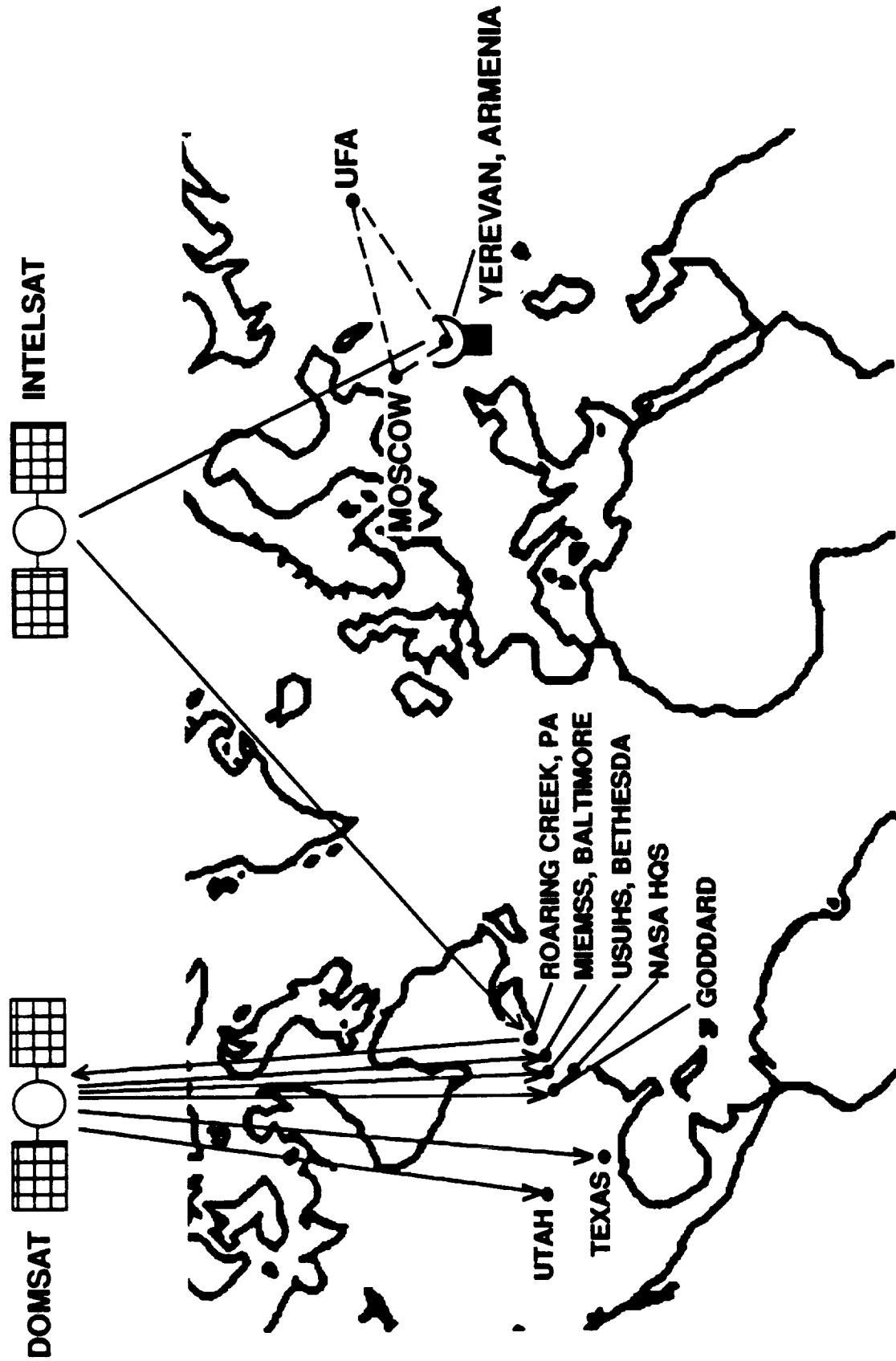
To accomplish the end-to-end service required coordination and cooperation of several different organizations. Primary organizations were: Satellite Transmission and Reception Specialists (STARS) of Houston, TX; the International Telecommunications Satellite Organization (INTELSAT); the Communications Satellite Corporation, (COMSAT); and the American Telephone & Telegraph Company (AT&T).

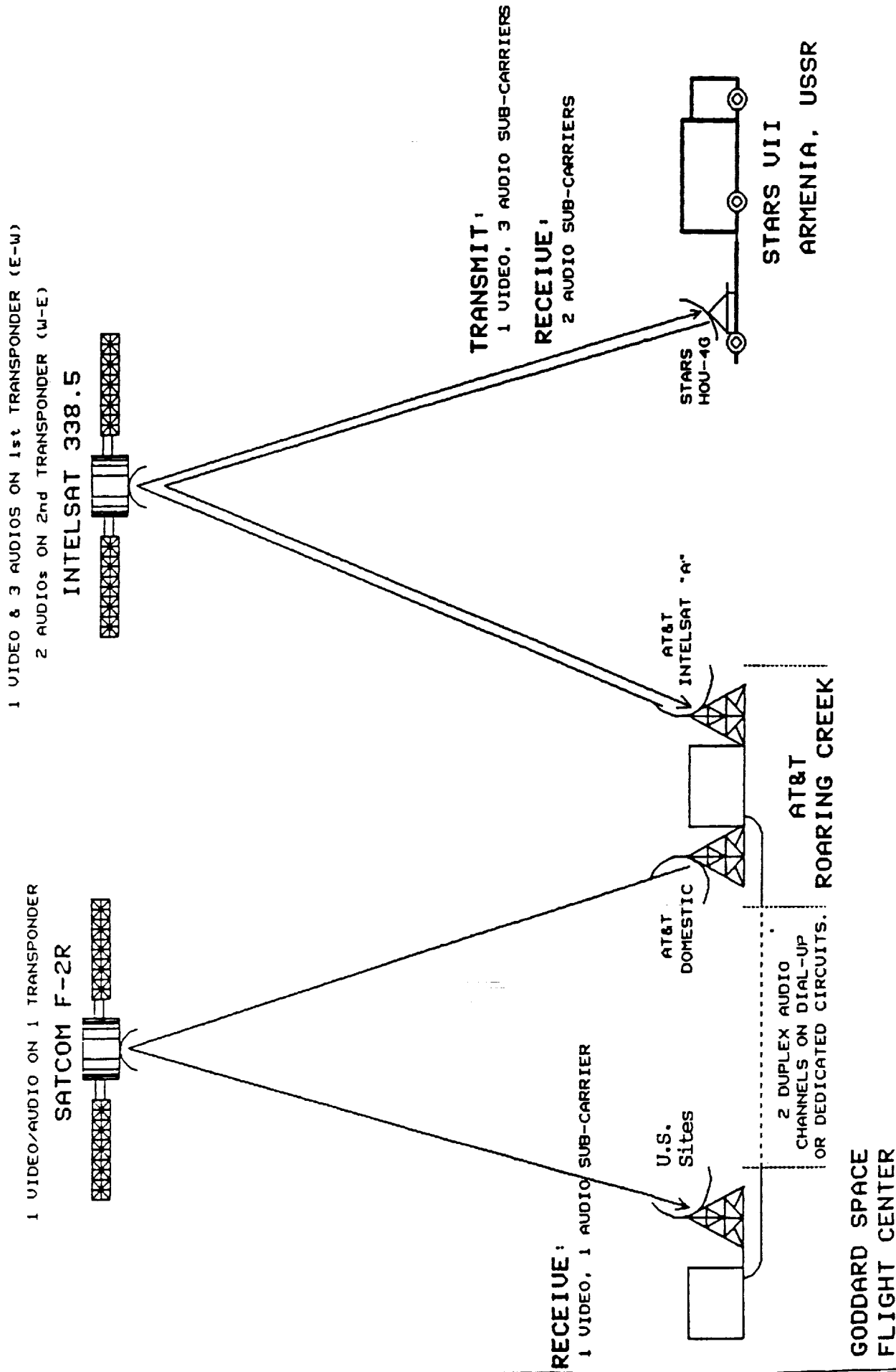
The U.S.S.R. Ministry of Post, Telegraph, and Communications and Gostel Radio Agency ensured that the frequencies utilized were available and free of interference. Furthermore, they provided free of charge down link capability and arranged communication links between Moscow and Yerevan.

STARS was the primary communications carrier involved in this service which consisted of a one way video channel from Yerevan to the U.S. and two duplex voice grade channels, one intended for the medical conference and one for communications coordination. Either voice grade channel could be used to support the Medical Spacebridge, but not simultaneously. The voice terminating equipment was equipped with a switch which would allow use either in the voice or facsimile mode. STARS

TELEMEDICINE SPACEBRIDGE

COMMUNICATIONS NETWORK





provided a transportable Earth Station and technicians in Yerevan. These technicians also assisted in the initial installation and training of hospital personnel in Yerevan in the use of the video, voice and facsimile equipment, in addition to the operations and maintenance of their facility. STARS was also the responsible party for obtaining all authorizations for the use of the INTELSAT transponders. On the international portion of this service, two transponders were used, one transponder was used for the video of and the accompanying audio channel while the other transponder was used for the two voice channels.

STARS also obtained the use of an AT&T earth station at Roaring Creek, PA to be used in conjunction with the STARS Yerevan earth station. Distribution of the Yerevan signal to the U.S. medical locations was planned to use a NASA obtained transponder on GE American Communications, Inc. domestic satellite, F2R. When the AT&T transmission from Roaring Creek to F2R caused interference to an adjacent satellite service, AT&T made available to STARS (and the Medical Spacebridge) a transponder on an AT&T COMSTAR satellite. The video signal with audio was downlinked to the U.S. medical locations. STARS was also responsible for the acquisition and installation of the receive only antenna and associated equipment at several locations. This arrangement provided near broadcast quality, (limited in quality by the camera's used) full motion video for the four hours, five days per week for approximately three months. At the request of the Soviet Union, the signal was also scrambled for the U.S. domestic broadcast, the scramblers and descramblers were provided by STARS.

From Roaring Creek, two private line voice grade services were installed to the Goddard Space Flight Center (GSFC). One service terminated there and was used as a coordination channel. The other was interconnected to a multipoint private line with terminations at all of the U.S. medical centers and NASA Headquarters. Simultaneous transmission of facsimile and voice could not be accomplished.

Along with the video equipment, cameras, monitors and VCRs, NASA provided the voice terminating equipment and the facsimile machine.

Daily coordination and monitoring of the Bridge was accomplished by the Bendix Field Engineering Corporation who has the operations and maintenance responsibilities for the Nascom Network.

The Soviet Government accepted additional communications links as a result of the Ufa gas explosion. NASA extended the Spacebridge to include black and white slow scan video and voice communications between Ufa and Yerevan for retransmission through the Spacebridge to the United States. This equipment was used because of the need to quickly establish simple to operate links using existing Soviet terrestrial voice circuits and infrastructure not capable of accommodating full motion video. It permitted adequate quality photo images of the burn victims, taken by Soviet physicians, to be transmitted every 20-40 seconds as well as audio teleconferencing.

This quick response was made possible by an intensive coordinated effort by the Soviet Ministry of Health and the Ministry of Post and Telecommunications. The slow scan video transceivers were donated by Colorado Video of Boulder, Colorado at the request of the Public Service Satellite Consortium (PSSC). PSSC provided telecommunications consultation in support of NASA and the USSR Ministry of Health.

The Soviet Union provided transportation of the STARS terminal, NASA provided equipment, and the STARS technicians to and from Yerevan as well as food and loading for the technicians while in Yerevan.

From a NASA Communications Network point of view the service quality was very good and most of the daily programming was accomplished with few impacts caused by communications problems.

Voice Communications

The major mode of communications used by the participants in the telebridge was voice communications. The high quality of the acoustics served to prevent difficulties in speech intelligibility.

Initially it was planned to use a single microphone to "cover" the entire conference room, with a second microphone available to the interpreter. However, it soon became necessary to eliminate the background microphone, since it was a source of interference when a large number of participants was present. In the second arrangement, two microphones with lower amplification were made available to teleconference participants, and a third was given to the interpreter. The microphones of the physicians, who spoke Armenian and Russian, served a purely psychological

support; the physicians felt more at ease when a microphone transmitted their words, even though what they said was not comprehensible to the listeners. Of course, hearing the intonations and emotional overtones of the speaker's voice was also useful, creating a situation that was closer to normal human communication.

The second microphone, which was left on in the majority of cases, was a continuing source of interference, since the person holding it and the people in his vicinity frequently forgot that their voices, along with that of the speaker, were being picked up. For this reason, for the final version it was decided to have only two microphones in the hall, one for the participants and the second for the interpreter.

A second acoustic channel, used mainly by the conference coordinator, was also important. First, it provided a link with the Goddard Flight Control Center, which constantly monitored communications and maintained the telebridge configuration; second, it was the "back-up" channel in case of interference or malfunction of the primary television acoustic channel.

Virtually the sole problem associated with voice communications was the frequent occurrence of feedback or echo (or, in the parlance of Soviet communications specialists, "snarl"). The source of this echo was a "hot" (switched on) microphone near the speaker. The transmitted voice was picked up by the microphone and transmitted with a delay along the voice channel, amplified for each transmission-reception cycle. The phenomenon occurred with variable frequency during many conferences, at times seriously disrupting the proceedings. The "echo" was more likely to occur when there were more medical centers participating in the conference. One means for eliminating this phenomenon would have been a push-button switch for the microphones ensuring that they were only on while pressure was maintained on the button.

Video Communications

The Armenia-U.S. video channel made it possible to hold full medical teleconsultations. As the project was being planned and developed, it was thought that it might be necessary to include a special digitizing device for transmitting x-rays and other medical images along the acoustic channels in the telebridge configuration, as it was feared that the quality of the images transmitted along the video channel would not be sufficiently high. However, this fear turned out to have been unjustified: the telebridge video channel satisfied all requirements.

The video channel served three major functions in the teleconferences:

1. *Visual access to the patient.* The attending physician conducted a physical examination which was observed by the consulting specialists. Throughout the period that the telebridge was operational there was not a single instance where the quality of the transmitted image was considered unsatisfactory. The color of the patient's skin, the condition of his mucous membranes, wounds, scars, and other changes observed during the examination were clearly visible in the U.S. medical centers. The high quality of the video transmission of movement is especially worthy of note. Observation of patient limb movements and gait is often critical to the evaluation of orthopedic cases. In neurological pathologies it was necessary to demonstrate tendon and other reflexes, disruption of motor coordination, etc. In consultations on patients with psychiatric problems, much attention was devoted to body language, facial expression, and appropriateness and other properties of movement. In addition, the video channel was used to transmit video records of such dynamic diagnostic procedures as fluoroscopy, endoscopy, ultrasound, and other diagnostic and therapeutic manipulations, as demonstrated in a video transmission from the University of Utah on June 28.
2. *Video presentation of medical images, curves, diagrams, charts, etc.* The transmission of medical images constituted a significant portion of the video transmissions for the telebridge. Many of these were images on a transparent x-ray film: x-rays, angiograms, computer tomography. These images were shown on a light box so that ambient illumination did

not have to be turned off. Images on nontransparent media (paper) — sonograms, curves, photographs, etc. — were visible under conditions of normal illumination. The majority of images were depicted in shades of grey — ranging from white to black. During the trial video-communication session, "grey scale" test images typically used for the adjustment of medical monitoring apparatus were transmitted. The receiving centers confirmed that all the gradations of grey on the test pattern could be distinguished. Thus, in combination with adequate accuracy (good resolution) and the good brightness-resolving capacity when the monitors were properly adjusted made it possible for the x-rays and other medical images to be transmitted virtually without loss of information. Some participants expressed the opinion that in many cases the transmitted image was superior to the original, due to the presence of a "zoom lens" that made it possible to magnify portions of the image, and also to automate brightness regulation. Thus, in the unanimous opinion of the Armenian participants in the Armenia-U.S. telebridge, there was no need for special equipment to transmit x-rays and other medical images. This was demonstrated by the level of detail with which the images were interpreted by the consulting specialists.

3. *To show the audience.* In the intervals between showing the patients and diagnostic images, the camera was directed at the physicians participating in the conference. It would be redundant to again emphasize the psychological value of this procedure above and beyond the medical information transmitted.

When the patient could not be present in the conference hall because of the severity of his condition, danger to others, medical contraindications, or great distance, visual observation of the patient was enabled by transmission of a video tape of a previous examination in the hospital ward. During the period the telebridge was in operation, consultations on more than 15 patients were conducted in this way. Such conferences included those focusing on infections in children, and were resorted to in the majority of the conferences on spinal pathology and neurosurgery. The playing of the video tape was accompanied by commentary from the conference hall. After the tape had been played, x-rays and other medical images were shown.

Aside from showing the patient himself, this use of the video channel made it possible to display the conditions under which the patients were being treated and to create the impression that the consulting physicians were present at and participating in the examination and treatment of the patients. The preliminary preparation of the videotape offered an important advantage in that it could be done without rushing, in the less frenetic environment of the hospital ward. The major shortcomings of this technique were that it precluded direct contact (conversation) between the consulting physicians and the patient, and precluded video transmission of additional symptoms not photographed when the film was prepared.

In the Ufa component of the telebridge, the output signal of the slow-scan transceiver was transmitted along the video channel. When the system (Colorado Video, model 250) was used, each static black-and-white image required 80 seconds to be transmitted along an ordinary narrow band telephone channel between the cities of Ufa and Yerevan. However, since discussion during the conference required a great deal of time, such slow transmission of the images did not disrupt the normal course of the conference. No complaints were made about the quality of the images. The only palpable shortcoming of the slow-scan video was the absence of color and movement. Sometimes there were differences of opinion among the participants concerning the suitability of slow-scan video for telemedical consultation. Professor John Siegel (Shock and Trauma Center, Baltimore), for example, expressed the opinion that the absence of color in the images could increase the chance of physician error. For consultation on burn patients, on the other hand, the consultants in Texas and Utah pronounced the slow-scan video "completely satisfactory." Overall, slow-scan video was deemed suitable for consultations on the majority of pathological conditions, and completely adequate for transmission of x-rays and other black-and-white medical images. Moreover, when x-rays are transmitted this technique permits preliminary processing to enhance essential details, which is an advantage of slow-scan video over ordinary television for transmitting x-rays.

The majority of participants in the telebridge regretted the absence of two-way video communications. This question must be posed as follows: do the advantages of two-way video justify the required expenditure of time and resources? A 2-hour experiment with the physicians at Utah showed that the advantages of transmitting video signals from the consulting centers to Armenia include extensive opportunities for teaching, the possibility for illustrating what the consultants are saying, and the

major positive psychological effect on the participating patients and physicians. Thus the answer to the question depends on the purpose and type of teleconference. In the "Armenia-U.S." telebridge, in which the conferences mainly involved teleconsultation, two-way video would be desirable, but would be unlikely to yield significantly new or major results.

Facsimile Communications

Facsimile communications, along with voice and video communications, were an enormous factor in the success of the "Armenia-U.S." telebridge. The facsimile communication line was used to transmit the following information from Armenia to the consulting centers:

- Medical data prepared according to an agreed format for the patient consultations
- Lists of participants in the conferences
- Lists of specific questions of the Armenian physicians
- Lists of literature requested by the Armenian physicians
- Corrected agendas for upcoming conferences
- Miscellaneous communications, requests, etc.

The following information was sent from the U.S. consulting centers to Armenia:

- Written consulting recommendations
- Literature on past or upcoming conferences
- Written answers to questions
- Lists of participants in the conferences

- Miscellaneous communications, etc.

Although the quality of the photographs, x-rays, etc. in the literature was considerably degraded in transmission, the overwhelming majority of the materials remained intelligible and useful. More than 1000 pages of medical information were transmitted while the telebridge was functioning.

Unfortunately, for technical reasons, facsimiles could not be transmitted during the conferences, so special communication sessions were devoted to facsimile transmission. During these sessions, all the technical personnel and communications apparatus were devoted to the facsimiles. Aside from saving time and resources, simultaneous facsimile transmission could have facilitated more efficient exchange of information during the conference.

In addition, since most of the information originating from Armenia was transmitted to more than one participant, the capability for transmission to two or more recipients would have been desirable. Another relative disadvantage of facsimile communication was the uneven rate of transmission. In most cases, transmission from Armenia to the U.S. proceeded at a rate of 9600 baud, while transmission in the other direction was almost always twice as slow, at 4800 baud. Nevertheless, both the quality and the content of the facsimile material received satisfied the majority of telebridge participants.

It is difficult to draw conclusions of the relative importance of one or another mode of communication in the functioning of the telebridge. To illustrate the utilization of all three modes of communication for consultations on a specific patient, we may cite one of the most interesting consultations, both from a medical and an technical point of view. This consultation involved a 9-year-old girl with cerebral paralysis and subluxation of both coxofemoral joints. Because of the unavailability of the appropriate consultant, the entire video presentation of the patient was recorded on video tape with detailed commentary. Detailed medical data were sent via the facsimile channel. A video cassette was then sent to a specialist in this specific area, who after studying all the data used a new technology of computer analysis of x-rays to plan orthopedic intervention. Along with the minutes of the consultation and the sources in the literature, a blueprint for the operation printed by the computer program for planning orthopedic operations was sent on the facsimile channel. In this example,

all three forms of communication were necessary to maximize the value of the consultation.

MEDICAL CONSULTATIONS

Communication equipment was installed in Yerevan in late April and early May with the first broadcast to the U.S. on May 4th. A patient with complicated pancreatitis was presented along with x rays in order to fully test the system. All the physicians felt that color television and voice transmissions were of excellent quality — furthermore, the transmission of x rays, CT, and ultrasound was surprisingly good. Translation (Armenian, Russian, English) was ably performed by one physician and an assistant in Yerevan. With this very successful opening broadcast, all of the participants enthusiastically anticipated the first earthquake casualty consultations.

As part of the Implementation Plan, a daily calendar for May and June was included which contained the subject matter to be discussed each day (See Supporting Materials). Furthermore, that U.S. medical center which had the most expertise was appointed lead for that day, although the remaining three centers were always invited to join in at any time. Usually two or three centers were on the air every day, each one contributing to the discussion regardless of who was designated the lead. In general, the scheduled consultations took place as indicated on the calendar, although at times some days had to be interchanged or modified because of unforeseen events or the unavoidable absence of clinicians or patients. Teleconference topics were selected on the basis of the specific needs of the Armenian physicians.

As the schedule went, there were broadcasts Monday through Friday (excluding U.S. and Soviet holidays), 9:00 a.m. - 1:00 p.m. EDT (6:00 p.m. - 10:00 p.m. Armenian time). Every Friday, Armenia would fax to the U.S. medical centers information on patients to be presented the following week. This then allowed the centers to prepare in advance for the discussion and to ensure the presence of the appropriate specialists. On the following Monday, the U.S. medical centers would then fax to Armenia journal articles and papers relative to the cases to be presented that week. On Tuesdays, Wednesdays, and Thursdays, the Armenian physicians would then present those cases for which they desired consultation. Frequently the patient was present and was examined in front of the camera; x ray, CT, and ultrasound studies were usually available as well. A lively exchange would then ensue, with particular emphasis upon management.

Communications sessions on Monday and Fridays, unfortunately, were clearly not efficient. For example, after communications had been established, it sometimes happened that the participants had not planned any transmission for that day or that the planned facsimile transmissions for that day would require only 1-2 hours. Therefore, on these days, the use of communications time was inefficient. It would have been possible to coordinate the transmissions needed for facsimiles and associated time requirements in advance, and use the remaining time more efficiently, for example, for short conferences on a very specialized area with a limited number of participants.

Subsequently, experience showed that if the number of conferences in a block exceeded four, it was expedient to divide the block into two sessions, separated by an interval of 1-2 weeks. Aside from psychological relief, this allowed time for the formation of interim conclusions from the results obtained, study of the literature that had been sent, and better planning of further telebridge activities on the particular topic.

In accordance with the mutual agreement of all participants in the conferences and organizations supporting communications, and taking account of the time difference of from 9 to 11 time zones, the conferences were held between 6:00 and 10:00 p.m. Yerevan time, which corresponded to 7:00 - 11:00 a.m. in Utah, 8:00 a.m. - 12:00 noon in Texas, and 9:00 a.m. to 1:00 p.m. in Maryland. Four hours were allocated to each conference. The Armenian physicians attended the conferences after their work day, while their American colleagues sacrificed work time. This was the sole mutually agreeable time interval.

The Armenian physicians disagreed about the duration of the conferences. Without doubt, 4 hours of high intensity work represented a significant mental strain for all the participants, especially the Armenian physicians. However, the great interest and practical benefit of the conferences prevented even a single participant from complaining of fatigue. A 10- to 15-minute break during the conference was a necessity, since by the end of the first 2 hours, the physicians sorely needed a short rest.

Ongoing planning and support of the functioning of the telebridge required major organizational efforts on the part of all participating organizations. The central

coordinating link in the telebridge structure was, without a doubt, the NASA Life Sciences Division. The medical coordinator on the American side, Dr. Russell Rayman, participated in all conferences, addressing on the spot any problems that arose. His colleague from Armenia, the director of the "Diagnostika" Scientific Productive Organization, Dr. Haik Nicogossian, was also always available.

The conference leader on the Armenian side, Dr. Ashot Sarkisian, also participated in all conferences. Since the majority of participants on the Soviet side were participating in teleconferences for the first time, substantial time was devoted to working out a format for presenting data and sequencing the various types of activity. The leader had to receive information on upcoming conferences ahead of time and arrange for its translation. His responsibilities included establishing communication, coordinating the conference agenda, and other administrative matters.

Groups were formed to consider each topic. Each group was composed of leading specialists who prepared the patients for the presentation and compiled documentation, lists of questions, and requests for literature. Two employees who knew English worked on alternate shifts in the studio: setting up the communications and notifying the appropriate individuals, copying and distributing material, preparing data for facsimile transmission, and filing.

A very positive factor was the powerful diagnostic capability of the institution in which the teleconference was organized and conducted. No fewer than half of the patients presented for consultation, some directly before or after it, were given additional examination in the "Diagnostika" organization.

The standard mode of presentation of patients' medical data, which had been agreed upon ahead of time, proved satisfactory. It was utilized in all cases when the working groups presented their data on time.

In cases where written information about the patient was sent in advance, repetition of the same information during the consultation was superfluous. Such time could have been used more efficiently for discussion of details, presentation of additional x rays, etc.

Quality of interpretation was one of the most important factors in the bilingual conferences of the "Armenia-U.S" telebridge. In the unanimous opinion of all

participants, the interpreter Valentina Simonenko was all that could have been desired. However, the following conclusions can be drawn. First, in a number of pathological states, translation into the patient's language plays a key role; for example, consultation on patients with psychological disturbances. Second, significant time can be gained by including a physician who knows both languages. Without being a professional interpreter, the physician is nonetheless capable of ensuring mutual understanding through short and accurate translation of the meaning of what has been said and through his knowledge of the basic terminology, Latin terms, equivalent terms for drugs, normal values of laboratory data, and a full understanding of what is being translated. Experience with the conferences showed that such a physician could significantly reduce the time required for interpretation. In conversation among colleagues, it was often possible to replace a long sentence with only a few words. The professional level of the interpreter Simonenko would have permitted simultaneous interpretation. However, the absence of the appropriate technical conditions and devices required interpretation that was primarily sequential. Of the two alternatives — sequential interpretation by a physician and simultaneous interpretation by a language specialist — the latter is definitely preferable.

The quality of the translation of texts transmitted to the consulting centers was also important. Lists of the questions discussed, lists of participants, and final patient data were sent via the facsimile channel after translation into English.

QUALITY OF THE CONSULTATIONS

Overall, the Spacebridge project, in spite of its complexities, was considered a great success by all parties. The telecommunications system performed magnificently, providing excellent audiovisual quality. Furthermore, the quality of transmission of x rays, CT, and ultrasound went well beyond what was expected by the physicians. The overall success of the communications network is attested to by the fact that only 2 of 55 broadcasting days had to be cancelled due to technical malfunction.

Discussion of how well the teleconferences were organized may begin with the words of one of the most active participants in the telebridge — Dr. Bruce Houtchens, a professor at the University of Texas: "When the right people are present, the right things get done." For the right people to be present at the conferences, it is essential to:

- Follow the schedule to the maximal extent; changes in the schedule must only be made well in advance.
- Send data on the subjects of the consultation no later than 3 days ahead of time.
- Prepare and send lists of very specialized questions well ahead of time, to allow time to invite the necessary consultants and prepare appropriate answers and material.

Of course, these requirements cannot always be met in every instance. Urgent consultations not stipulated in the plan naturally may force exceptions. However, in planned medical teleconsultations on the "Armenia-U.S.A" telebridge, such cases should occur only 10 percent of the time, while in actuality they constituted 50 percent of all the consultations.

It is very important that each teleconference be well organized. The conferences proved most useful, interesting, and substantive when they were carefully prepared ahead of time, and structured to constantly retain the interest of the participants. The most interesting conferences were those in which:

- Patients were actually presented. Experienced practitioners eagerly discussed differential diagnoses, examined x rays, and sought confirmation of their hypotheses, consulting with each other. When the patient was present in the hall, he was virtually always asked additional questions. Many questions were asked of the attending physicians.
- Discussion of pathogenesis, therapeutic or diagnostic methods followed specific consultations or, in other words, the patients were selected in accordance with the issues discussed.
- There were few or no long speeches or analyses by individual participants that went beyond the limits of the specific issues discussed.
- Specific questions were asked that required specific answers.
- The format of presentation of the patients was appropriate; information about the patient was objective and unbiased
- Information about the patients was sufficient.

Sufficiency of the information provided played a direct role in determining the efficacy and completeness of the consultation. The reluctance of consultants to base their conclusions on insufficient information, and to replace conclusions by guesses, must be understood. An example might be the nephrological patient whose diagnosis was unclear and for whom kidney biopsy data was lacking. The availability of these data would have diminished the likelihood of differential diagnoses, and the consultant would have been more confident that the treatment he recommended was appropriate. Unfortunately, in a number of cases the attending physician did not bring all the x-rays, encephalograms, etc., to the conference. The reluctance of participating consultants to blindly accept oral descriptions was understandable.

It is essential to note the psychological strain on the consulting specialists. During the consultations they had not only to express their opinions, but to justify them, and even convince the other participants of their correctness.

A great deal of attention was given to deontological issues during the functioning of the "Armenia-U.S." telebridge. On U.S. territory, the video signal was propagated in a coded form, in order to guarantee the medical privacy of the patient and avoid accidental reception by private individuals or nonmedical organizations.

The period in which the patient was presented and the period during which his case was discussed were strictly separated in the overwhelming majority of cases. That is, after the patient was examined and questions put to him, he was asked to wait in an adjoining room, with the understanding that he might again be asked to come to the hall during or after the consultation.

The physicians were not the only participants who were disappointed with the absence of video transmission from the consulting centers. The patients were even more disappointed that they could not see the consulting physician, in whom they had placed such great hopes. The opportunity to see the physicians undoubtedly would have had a positive psychological effect.

AREAS OF CONSULTATION

While the "Armenia-U.S." telebridge was in operation there were 31 thematic conferences (i.e., conference devoted to a single topic), in which 230 physicians participated on the Armenian side and 405 on the American side. During approximately 124 hours of work, consultations were held for more than 200 patients, about 30 of whom were present at the conferences. (Cf. Table 1). As the table shows, the conferences covered more than 13 medical specialties.

Of the 230 physicians participating in the conferences, more than 60 were lecturers at the Yerevan Medical Institute and Yerevan Institute of Advanced Physician Training, including more than 20 who regularly lecture to specialists, 50 directors of medical institutions, 10 chief specialists and directors of branches of the Armenian Ministry of Health, and 9 foreign physicians.

The medical results of the teleconferences were deemed significant by all groups of specialists. These results can conveniently be categorized according to the major focus of the the physicians during the conferences (Cf. Table 2).

As the tables show, the medical results go far beyond consultative aid for individual patients. Unlike the majority of past experiments, here the patients were introduced by their own physicians, who frequently were specialists in their area. It should be noted that in approximately 25% (53 of 210) patients, the diagnosis was changed after consulting with the U.S. specialists.

The following discussion of the medical results of the conference is organized according to conference topic.

Surgical Conferences

A leading role in teleconsultations on surgical patients was played by visual information — pictures of the locus of injury, gait and other physical signs, and also a large number of x rays, tomograms, etc. This was equally true for orthopedic, spinal, and neurosurgical cases. Laboratory data and the results of general physical examinations played a much more minor role in these cases. Surgical

Topic	# Confs	Total Hours	Table 1 # Physi- cians	# Consul- tations	Pages Facs	Group Eval.
Surgical group	5	20	38	44	232	
Psychology	7	28	24	25	451	
Epid/Infec.	4	16	42	5	69	
Int.Disease	1	4	13	5	--	
Diagnostic visualization	2	8	33	33	79	
Laboratory med	1	4	14	--	77	
Burns/Ufa	5	20	14	24	20	
Vascular surgery	1	4	5	16	25	
Endocrinology	1	4	11	5	--	
Ophthalmology	1	4	25	6	51	
Neurology	1	4	8	4	--	
Urology	1	4	3	25	--	
Dialysis	1	4	17	6	30	
Total	31	124	230	210	1026	

Table 2

	# Consul- tations	Altered diagnos	Altered treat	Recommms for new studies	Altered diagnos process	Altered interp. of diag results	Intro.of new treat method
Surgical group	44	0/21	12	30	16	2	5
Psychology	25	1/8	17	3	--	--	3
Epid./inf.	15	2/2	4	7	5	2	1
Int. disease	5	0/1	2	2	2	1	-
Diag. visual	33	4/10	--	12	12	15	--
Lab. med.	-				5	4	
Burns	24	--	XX				
Vasc. surgery	16	0/7	1	5	4/?	3	1
Endocrinology	5	1/1	2	2	--	--	2
Ophthalmology	6	1/2	1	--	--	--	1
Neurology	5	1/1	3	2	2	--	1
Urology	25	--	5	7	1	--	2
Dialysis	6	1/1					
Total	210	9/53	47	70	47	27	16

teleconferences were devoted to discussion of methods of treatment since, as a rule, diagnosis was not subject to doubt.

The first surgical conference was held on May 18th. The leading orthopedists and traumatologists of the Republic and directors of the traumatological services in the earthquake zone participated in this conference. The first to speak was the Chief Specialist of the Ministry of Health, Ruben Nicogossian. He described in detail the situation that had developed in the disaster area and in the Republic as a whole and spoke of the procedures for evacuating trauma patients and of the measures taken to provide the most effective aid to the victims at all evacuation stages. Next, physicians from the disaster area spoke. Then 12 patients, the majority of whom had suffered trauma during the earthquake, while two suffered from severe osteomyelitis, and two others from complications following burns, were presented and discussed.

The conference on reconstructive and plastic surgery and transplantation of soft tissue generated a great deal of interest. Physicians from the two major departments devoted to this field in the Republic posed many questions that had arisen during the treatment of the victims, and a major portion of the conferences was devoted to discussion of techniques for various kinds of surgical interventions. The Armenian physicians were given many recommendations with regard to surgical treatment of bed sores and postburn and post-traumatic damage to soft tissue. Consultations were held for six patients.

The conference of May 30th was the most tightly organized. After visual presentation of three spinal patients accompanied by discussion of certain aspects of spinal surgery, the physicians turned to issues of spinal rehabilitation. At this conference, the method of playing video tapes made previously was first used. After a patient with bed sores was shown, questions were put concerning the treatment of bed sores; after a patient with particular ossification was presented, relevant questions about this complication and its treatment were raised.

The recommendations of American specialists on questions of spinal rehabilitation were very useful. The newly established Center of Spinal Rehabilitation in the city of Yerevan, staffed with young specialists without a great deal of experience working with this category of patients, received a great deal of essential information.

The next conference, to be devoted to orthopedics, was interrupted at the very beginning by an urgent unscheduled consultation. A pediatric physician in Salt Lake City, who had been called in specially, held a consultation on a 9-year-old child with severe pulmonary pathology. This consultation could be called one of the most effective -- it resulted in alteration of the diagnosis, and a program of further examination and treatment was recommended. After this child was seen, consultations were held for five orthopedic cases.

The final conference, devoted to neurosurgery, was very substantive. Consultations on individual patients were followed by animated discussions of the efficacy of various diagnostic methodologies and different methods of treating brain injuries.

Many pages of printed information relevant to surgery were received. In addition to the literature requested before or during the conferences, the Americans kindly sent the latest review articles of potential utility to the Armenian physicians. Works on internal fixation of the thoracic portion of the spinal column, classification and treatment of osteomyelitis, retrograde cholangiopancreatography, and many other topics were gratefully received. At the request of the Armenian physicians, articles were sent concerning easing or eliminating causalgic pain in patients suffering from crush syndrome.

These and other materials transmitted by facsimile communications could, and in the opinion of the Soviets, definitely would have a discernible positive influence on the diagnosis and treatment of the relevant categories of patients. The majority of the works obtained were xeroxed and distributed to participants in the conferences. Nonduplicated works were given to coordinators for the appropriate specialties for further dissemination.

Epidemiological and Infectious Diseases

Any of the four conferences held on this topic could be used to demonstrate the expediency and utility of the selection of this subject. The first conference (May 10th, first telebridge conference) was devoted to the epidemiological situation that had developed after the earthquake. The participation of many specialists, including the directors of the Epidemiological Service of the Republic and affected regions and cities, and consideration of the monthly patterns of the incidence of particular diseases

before the disaster, made it possible to find optimal solutions for limiting and eliminating foci of infection if the epidemiological situation were to become more severe. In particular, there was discussion of different scenarios for incidence patterns of acute upper respiratory infection and intestinal infections due to the disruption of water supply and waste disposal systems, food supplies, and prophylactic and therapeutic services in the affected regions. The American colleagues agreed that only those infectious diseases that had been recorded previously or for which the causal agent had been identified in one or another local natural environment were likely to be activated.

Among the pathologies discussed, the most frequently mentioned were bacterial and amebic dysentery, salmonellosis, viral diarrhea, viral hepatitis, toxic infections from food and food poisoning, and meningococcal infections. Also considered were factors such as the death of a large number of [domestic] animals and increase in rodents, including rats. The Armenians described the set of preventive measures that had been taken.

The American physicians were informed of the results of mass operational induction of phagocytic immunity to particular intestinal infections and the use of Interferon to prevent acute upper respiratory infections and judged that these measures were adequate. Certain administrative aspects of epidemiological monitoring of the developing situation were discussed; particularly with regard to cities suffering substantial damage that had had adequate systems of structures for preventing the spread of infection before the catastrophe.

The second conference, devoted to the problem of viral hepatitis, was attended by 18 physicians from Armenia, including 14 from the disaster area, and more than 12 physicians from Bethesda and Utah.

Discussion of the first case lasted 50 minutes. Although the discussion of this very complex case did not resolve the question of concomitant polyarteritis nodosa or persistence of the hepatitis B antigen from the outset as possible reasons for the development of hepatitis, useful advice was given concerning future management of the patient. The soundness of this advice was confirmed by tracking of the antibody titer.

During the discussion, many different approaches to the use of drugs in hepatitis and many different ideas about the efficacy of diagnostic tests came to light. At the end, the American specialists answered questions concerning sensitivity and specificity of particular methods for diagnosing leptospirosis.

The third meeting — on May 17th — was attended by a total of more than 45 specialists. The first half of the conference was spent exchanging experience concerning diagnosis and treatment of viral hepatitis in children. The American physicians provided interesting and useful material on the combination of AIDS and hepatitis B. After a break, the question of treating a child believed to have both hepatitis and yersiniosis was discussed. The consultants argued cogently that the patient did not have a viral infection of the liver and proposed measurement of the hepatitis B antigen as a differential test. The American participants were interested in the extensive use of antioxidants in Armenia. The Armenian specialists sent material concerning their experience and scientific research in this area by facsimile communication.

The fourth conference was devoted to intestinal infections and also to analysis of the most severe complications of infectious pathology, such as toxic shock, hemorrhagic syndrome, and neuritis. The specialists from Bethesda kindly agreed to provide written answers to questions on botulism. The discussion of means for correcting disruption of fluid-electrolyte and acid-base balance in children, including neonates, was very productive.

The Armenian specialists characterized these conferences as "very effective and useful." There is no doubt that these conferences will have a long-term influence on diagnostic and therapeutic tactics for the diseases discussed.

Many pages of printed material on problems of interest to the Armenian specialists were received by facsimile communication. All the material obtained was xeroxed and distributed to the appropriate groups.

Psychology and Psychological Rehabilitation

The conferences on psychology and psychological rehabilitation generated special interest on both sides of the "Armenia-U.S." telebridge. The experienced

professionals working on both ends of the telebridge turned the conferences into absorbing exchanges of opinions, discussion, and debate.

Only the topic of the conference was agreed upon in advance. The psychologists did not consider it essential to send lists of questions or patient data ahead of time. Post-traumatic stress disorders, the effect of the catastrophe on families and children, drug therapy in psychological rehabilitation, group psychotherapy, the use of the mass media, mass examination of people who had been compelled to leave their homes, remote consequences of a major catastrophe with regard to psychological health of the population, effects on individuals already under stress — this is an incomplete list of the problems addressed at these conferences.

Significant emphasis was placed on the psychological effects of the earthquake on medical personnel of the disaster zone, the influence of stress on their work capacity and professional capabilities. Organization of appropriate and complete psychological and psychiatric aid for the population of the disaster zone was considered the most important issue.

It should be noted that before the earthquake, Armenia did not have an adequate independent psychological [aid] service — this service was still in the developmental stage. The small group of psychologists/physicians available were not capable of coping with the severe consequences of the earthquake on the psychiatric health of the population without help from psychiatrists. The Mental Health Center was established after the earthquake. The newly appointed director of the Center, was one of the most active participants in the teleconferences.

Little Conferences

The 10 "little" conferences in 9 medical specialties also were a great success. Of special interest, in the opinion of the Soviet participants, were the conferences on diagnostic visualization, dialysis, vascular surgery, and ophthalmology.

The conference on dialysis coincided with a period of rapid development of this treatment method in Armenia. During the preceding months, a large number of new dialysis centers had been established in the Republic and new specialists in dialysis were trained. The conference gave the physicians the opportunity to receive answers

to many questions that had arisen during the period after the earthquake. Their American colleagues congratulated the Armenian dialysis specialists on their success in treating a large number of cases of crush syndrome associated with the earthquake.

The two conferences on diagnostic visualization permitted discussion of problems of computer tomography, nuclear medicine, x-ray technology, and ultrasound diagnosis. Aside from the many dozen medical images, more than 30 patients whose diagnostic data offered certain interpretation problems were presented for discussion. Before the conferences, the consulting centers had received facsimile material listing questions, to which they provided exhaustive answers during the conference. As a result of the consultations, the interpretations of many diagnostic images were modified. The Armenian specialists received valuable advice concerning improvement of many diagnostic methodologies.

During the conference on vascular surgery, the American physicians provided consultation on 16 patients. This was one of the most animated and interesting conferences held on the telebridge. A technical innovation in this conference was the demonstration of colored slides made during an operation. A sensitive video camera of high quality transmitted the frames projected on the screen of the slide projector.

The conferences on ophthalmology, urology, endocrinology, laboratory diagnostics, and internal diseases were very effective.

CONSULTATION TO UFA

After the Ufa train accident on June 4th, further communications arrangements became necessary in order to link the Ufa Burn Center with the existing Spacebridge. Because of a short lead time and urgency of the situation, it was decided to link Ufa with Yerevan (by land lines) where all transmissions could be patched into the existing Spacebridge and retransmitted to the U.S. This add-on system was capable of two-way voice communications and black-and-white slow scan video. The slow scan video transceivers and camera equipment (at the request of Public Service Satellite Consortium) were generously donated by Colorado Video of Boulder, Colorado. Transportation to and from the U.S.S.R. was provided by Aeroflot.

Transmissions from Ufa began on July 5th and terminated July 12th. Twenty-four patients were presented during this week, with most of them having severe burns. In addition to these cases, there was much discussion concerning general burn treatment, grafting techniques, fluid replacement, and antibiotic prophylaxis. Several hours were also given to psychological problems following burns, particularly those that caused disfigurement of the face.

The Ufa consultations went very well considering the requirement to begin consultations after only a few days' warning. This precluded the use of color video, leaving no alternative other than slow-scan black and white. With slow scan, a still picture of the patient is transmitted every 20-40 seconds. Hence, there was not only no color, but also no movement. Although the American doctors would have preferred full motion color video, given the constraints of the situation, the still-frame photos, strongly supplemented by audio interacting, were considered adequate for its purpose.

RESULTS

Virtually every Soviet and Armenian physician who participated in Spacebridge felt it was highly successful, that it was worthwhile, and that they would participate in a similar such operation again if given the chance.

Spacebridge was an unqualified success, demonstrating that medical care can be effectively delivered through a telecommunication system. It was an example, par excellence, of space age technology helping man to cope with a down-to-earth tragedy.

As a result of this experience, it was concluded that there are four major applications for telemedicine: patient presentations; discussion of general medical topics; diagnostics; and education. For disaster situations, this can be best done if all arrangements were made in advance with participating medical centers and that international agreements addressing communications and funding in particular be negotiated beforehand. With prearranged agreements, a telemedicine system could be installed and operational in the very early phases of a disaster (at 24-28 hours) as well as during the rehabilitation period.

Of utmost importance is good two-way audiovisual capability and a system to permit faxing independently. Although Spacebridge was not capable of televising from the U.S. to Armenia, the LDS Hospital in Salt Lake City was able to arrange televising back to Armenia 2 hours of consultation demonstrating its value. The use of slow scan video received mixed reactions by the U.S. physicians because it was neither in color nor capable of transmitting movement. It would be of value, nevertheless, if regular television was not available. It was also further noted that it transmits diagnostic imaging pictures very well.

The participants agreed that use of broadcasting time is far more efficient if all presentations are scheduled in advance and that the consultations proceed accordingly. This is the only way to ensure that the appropriate specialists are available at the right time for the right patients. Otherwise, the patient will not get the full benefit of specialty consultation. Spacebridge clearly demonstrated that with the proper specialists on hand, as well as complete patient information, including x rays, there will be a direct salutary impact upon diagnosis and treatment. Because of the

success of Spacebridge, the Soviet and U.S. participants unanimously agreed that it should be continued and that efforts should be made to establish an on-call international capability. To this end, a briefing was given on September 11th to a number of Federal agencies involved in disaster response.

General conclusions of the group were as follows:

- a. Spacebridge succeeded at the technical and medical level. It satisfied the objectives to demonstrate on an international level and was adaptable to changing circumstances.
- b. Although medicine and telecommunications have an evolving relationship, specific needs challenge our capacity for compatibility.
- c. International constraints were more substantial than technical or medical considerations to implement the program.
- d. The program led to substantial changes in diagnostic and therapeutic outcome for specific patients, and new technologies in diagnosis and treatment were introduced.
- e. The value of the program extended far beyond the immediate needs of the disaster.
- f. The program accumulated a unique body of information, technical and medical, of international value.
- g. The program established a new and enduring relationship between the medical communities of the U.S.S.R. and U.S.A., involving hundreds of physicians and other health care personnel.
- h. The common ground and sophistication of medicine in Armenia and U.S.A. permitted detailed recommendations about specific patients facilitated by high quality telecommunications.

- i. The practice of medicine via a telecommunications system has direct application to the care of astronauts in space.

An important outgrowth of this program has been the increased awareness of the medical, technical and political institutions of the use of satellite communications for disaster medicine.

Several participants are involved in proposals to continue and expand the Space-bridge concept on a world-wide permanent basis. They are also investigating approaches to reduce its technical, administrative and regulatory complexity and to reduce its cost.

Proposals are also being developed to establish international agreements that would include provisions for facilitating frequency assignments and entry and operations of relief teams and their communications and rescue equipment into foreign countries for disaster relief.

RECOMMENDATIONS

Because Spacebridge to Armenia and Ufa was an unprecedented experiment, much was learned in its planning and execution. During the broadcasts in late June, a few hours were given to lessons learned to make some mid-course corrections. However, in order to have a full, detailed discussion, and to write a final report, representatives from the Soviet Union were invited to Washington, DC, September 8-11, 1989 to meet with their American colleagues. The product of this meeting was this joint Spacebridge report, recommendations, and a Protocol. We hope this experience will serve others should tragedy occur.

1. A Spacebridge telecommunications system should be available for world-wide deployment in event of disaster.
2. International agreements should be negotiated in advance of disasters to address implementation and funding to ensure an unhampered rapid response.
3. National or international organizations should be identified which will take the responsibility for action in the future, to include organization, funding, and implementation.
4. The responsible organization should maintain an updated resource data base to include critical personnel, satellite coverage, etc.
5. Prior to the inception of such a project there must be an analysis of cultural and medical practices to establish a common language for lab instruments and data, medical technology, pharmaceuticals, surgical instruments, etc. Pharmacopeias should be exchanged.
6. A subgroup (mainly spacebridge to Armenia and Ufa participants) should be formed for the purpose of
 - a. finding a national or international organization to continue spacebridge
 - b. transferring its telemedicine expertise and knowledge to other appropriate agencies.

- c. completing the analysis of data, organizing international workshops, and preparing joint publications in Russian and English.
- 7. A permanent subgroup under the auspices of the Soviet-U.S. Space Biology and Medicine Joint Working Group should also be formed for the purpose of
 - a. standardizing telemedicine procedures in space.
 - b. providing experts to deal with emergency needs in space flight.
 - c. supporting research to advance telemedicine support for space flight and facilitating development and evaluation of space medicine to provide optimum medical care to man in space.
 - d. advising as to how space telemedicine advances can best be applied to terrestrial medical needs.
- 8. Medical centers with comprehensive specialty services should be preselected for Spacebridge operations and its staff trained for telemedicine operations. Specialty consultation should be available for pediatric and burn cases. All participating medical centers must be committed and ready to respond on short notice.
- 9. There should be a two way video so patients and consultants can see one another. Also should consider telecommunications to demonstrate techniques in the operation room.
- 10. There should be capability to fax simultaneous with audiovisual transmissions.
- 11. Patient presentations and discussions should adhere strictly to prearranged schedules to ensure that the proper specialists are available. With undependable scheduling, specialists may be absent which will result in a deficient consultation.
- 12. Conferences can be of 1-4 hours duration with scheduled breaks.

13. A common consistent format for patient presentation as well as for fax'd material is essential.
14. FAX material must be sent ahead of time to ensure proper presentation and availability of the appropriate consultants at the right time.
15. A proper facility for patient presentation including physical examination is essential.
16. Use keyed microphones to avoid echos.
17. Consider use of digitized video for 2-way capability.
18. Translation, written and oral, should be given high priority. (Simultaneous translation would be advantageous.)
19. Critical communication elements include FAX, audio, and video. Optimal would include two-way color video with color slow-scan video availability.
20. Use slow scan as an alternative to regular video.
21. Begin any Spacebridge project with overall description of the disaster and video if possible of the disaster area to be viewed by participating consultants.
22. Must know cases in advance, presented on time with right specialists in the room at the right time.
23. Advantageous to have skilled presenters who can do a good physical examination on TV.
24. Telemedicine should be part of medical school curricular as it will probably be a part of private practice in the future. Techniques need to be developed to make it as effective as possible.
25. Should have pointer capability for imaging and patient examination.

26. All x rays of patients to be presented should be on hand.
27. Develop through sustaining and educational programs, international teams which could respond promptly to implement the programs.
28. The data from the program should be analyzed in a scholarly way to permit joint publication coordinated by Drs. Arnauld Nicogossian and Haik Nikogossian.

SUPPORTING MATERIALS

- A. Initial Protocol
- B. Implementation Plan
- C. Calendar Schedule
- D. Weekly Status Reports
- E. Final Protocol

